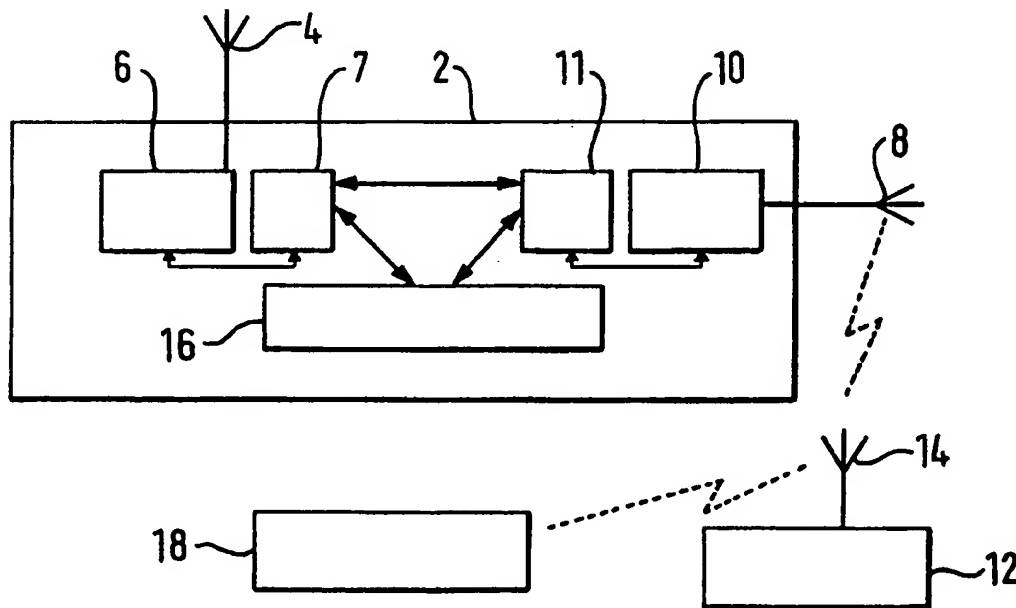




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>H04B 17/00, 1/10, 1/713</b>	<b>A1</b>	(11) International Publication Number: <b>WO 00/04658</b> (43) International Publication Date: 27 January 2000 (27.01.00)
<p>(21) International Application Number: PCT/EP99/04666</p> <p>(22) International Filing Date: 5 July 1999 (05.07.99)</p> <p>(30) Priority Data: 9815391.9 15 July 1998 (15.07.98) GB</p> <p>(71) Applicant (for all designated States except US): TELEFONAKTIEBOLAGET LM ERICSSON [SE/SE]; S-126 25 Stockholm (SE).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): BRISTOW, Robert, Owen [GB/GB]; 9 Sonning Close, Basingstoke, Hampshire RG22 5JJ (GB). MATTISSON, Sven [SE/SE]; Majorsvägen 1, S-237 32 Bjärred (SE).</p> <p>(74) Agent: O'CONNELL, David, Christopher; Haseltine Lake &amp; Co., Imperial House, 15-19 Kingsway, London WC2B 6UD (GB).</p>	<p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</p>	

(54) Title: INTERFERENCE PREVENTION IN A RADIO COMMUNICATIONS SYSTEM



## (57) Abstract

In a radio communications unit with several transceivers communicating in different frequency bands, a signal parameter of a selected channel is monitored in order to detect interference due to intermodulation products. The select channel is for example used by a long range radio communications link and the interfering channel on a short range radio link. Once the channel causing interference has been identified, transmissions on it are prevented.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## INTERFERENCE PREVENTION IN A RADIO COMMUNICATIONS SYSTEM

### TECHNICAL FIELD OF THE INVENTION

This invention relates to a radio communications unit, and in particular to a unit of the type which communicates over a network with a satellite or cellular system, and which communicates over a short range radio link with a remote unit such as a portable handset. In particular, the invention relates to a unit of this type in which interference, on a channel over which the unit communicates with the network, caused by transmissions on the short range radio link, can be avoided.

### BACKGROUND OF THE INVENTION

Radio communication units have been proposed, having one transceiver for communicating over, say, a satellite network, and a second transceiver for communicating over a short range radio link with a remote unit such as a portable handset.

A potential problem with such units is that, if there is a third party transmitter located close to the unit, or to the remote handset, operating in a nearby frequency band, it may together with the transmitter on the short range link produce intermodulation products which can interfere with reception of signals on the long range communications link. Typically, the short range radio link uses a frequency hopping system, in which communications are transmitted over a large number of channels, which are used in sequence. It is probable that only one of these channels will, together with the third party signal, produce an interference signal on the channel used by the long range radio link.

Various systems are known for avoiding interference. For example, EP-0781066 describes an arrangement in which interference signals are monitored on a number of channels, and channels with unacceptably

-2-

high levels of interference are not used. WO95/08246 discloses a frequency hopping system, in which interference levels are monitored on the available channels and, if it is determined that the interference level on a channel is high, this channel can be discarded from the frequency hopping sequence which is used.

Thus, these systems involve detecting interference on a particular channel and, when interference is detected, avoiding the use of that channel.

#### SUMMARY OF THE INVENTION

In accordance with the invention, the problem which is sought to be solved involves interference on a channel used by one transceiver, caused by transmissions on a different channel by another transceiver.

In accordance with the invention, the interference is detected on one channel, for example used by a long range radio communications link and, if interference is detected, use of another channel, for example on a short range radio link, which is causing that interference signal to appear is suspended.

This allows the unit to continue communications with the network on the already allocated channel, altering only the pattern of communications on the short range radio link.

#### A BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a block schematic diagram of a radio communications unit in accordance with the invention.

Figure 2 illustrates the frequency bands used by the unit, and the signals appearing therein.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows a system in accordance with the invention. A radio communications unit 2 includes a first antenna 4, connected to transceiver circuitry 6, for communication over a radio communications network.

-3-

In this illustrated embodiment of the invention, the transceiver circuitry 6, and antenna 4, are adapted for communication over a satellite network, transmitting signals to and receiving signals from low orbit  
5 satellites, with received radio frequency signals in the range from 2480MHz to 2500MHz.

However, it will be appreciated that the invention is applicable to systems operating over other radio communications networks, for example cellular networks.

10 The transceiver module 6 is connected to a baseband and control module 7, to which it sends received data signals, and from which it receives data signals for transmission and tuning and power control data.

15 The unit 2 further comprises a second antenna 8, and transceiver circuitry 10, for communications over a short range radio link. The transceiver module 10 is connected to a baseband and control module 11, to which it sends received data signals, and from which it  
20 receives data signals for transmission and tuning and power control data. The baseband modules 7, 11 are connected together for the transfer of voice or other signals received on one RF link for transmission on the other RF link.

25 Figure 1 also shows a portable handset 12, having an antenna 14, for communication over the short range link with the unit 2.

Although in this illustrated embodiment the unit 12 is described as a portable handset, it will be  
30 appreciated that this unit may be any device which is located remotely from the main unit 2, or at least is movable relative thereto.

The system 2 further comprises a controlling and interfacing unit 16, which controls the overall  
35 operation of the device, and, in particular, sends and receives signals to and from the baseband and control

-4-

modules 7, 11. Specifically, the control unit 16 receives data from the satellite baseband and control module 7, relating to the satellite link, such as the quality of the link and the channels which are in use. The control unit 16 then includes the relevant circuitry for detecting interference as discussed below, and issuing control signals, in particular for the control of the short range link. The baseband modules 7, 11 and control unit 10 may be separate only in the software domain, without being separate physical devices.

The short range radio link, between the main unit 2 and remote unit 12, operates in the Industrial Scientific and Medical (ISM) band of the radio frequency spectrum, from 2400MHz to 2480MHz (see document IEEE 802.11). This has the advantage that, in many countries, users do not need to be licensed. However, a consequence of this is that signals may need to be transmitted in the presence of large interfering signals in the same band. For example, there may be other nearby communications users, but even microwave ovens can transmit relatively large signals in this frequency band.

Figure 1 shows such a source 18 of interfering signals.

In order to allow the short range radio link to operate successfully in the presence of such potentially interfering signals, it uses a frequency-hopping spread spectrum (FH-CDMA) system. This means that there are a large number (perhaps 50 or 100 or more) of channels allocated for transmissions on the link, and the transmissions take place on each of these channels in succession, using a predetermined pseudorandom sequence. In a preferred embodiment of the invention, 80 such channels are used. Although there may be interference on a small number of the

-5-

channels which are used, only a small proportion of the total data will be lost. Then, data interleaving, and error correction, can be used to ensure that errors as a result of the interference do not occur together in bursts within the received signal, and can be compensated.

However, this does not apply to the transmissions sent to the satellite network, which use direct sequence spread spectrum (DS-CDMA), operating on a single channel at a time.

Figure 2 is a representation of the relevant part of the frequency spectrum, illustrating the relevant signals. As mentioned above, the ISM band, in which the short range radio link transmits, is from 2400MHz to 2480MHz. The transceiver 6 receives signals from the satellite on a channel in the frequency range from 2480MHz to 2500MHz.

As also mentioned above, the short range radio link operates on a frequency hopping principle, which means that it uses a large number of channels in the relative frequency band, in predetermined sequence, each for only a short time. Figure 2 shows a signal appearing at one such frequency in the ISM band. Also shown in Figure 2 is a signal 32, appearing at a different frequency in the ISM band. As mentioned above, this signal may be transmitted by another unlicensed communications user, or may even be emitted by a non-communications source, such as a microwave oven.

As is known, nonlinearities in the RF components of the receivers will cause intermodulation products to be developed when the signals 30, 32 are combined. The third order intermodulation products, indicated in Figure 2 by the reference numerals 34, 36, will appear to either side of the two original signals 30, 32.

Thus, as shown in Figure 2, the intermodulation

-6-

product 36 appears in the receive band of the transceiver 6. Therefore, assuming that the signal 32 is at a constant frequency, then, as the frequency of the signal 30 hops from one channel to another, the intermodulation product signal 36 will appear at different channels in the same sequence.

When the intermodulation product signal 36 appears on a channel on which the transceiver 6 is attempting to receive signals, it will cause severe interference with those signals. Moreover, because the transceiver 6 is receiving on a constant frequency this will cause data to be lost.

In accordance with the invention, therefore, steps are taken to prevent transmission on the relevant channel in the ISM band which is causing the intermodulation products to appear at the channel which is in use by the satellite transceiver 6.

The first stage is to identify the relevant channel in the ISM band which is causing the interference to appear on the satellite channel which is in use. There are many ways in which this can be done.

For example, the quality or signal strength of signals received by the transceiver 6 can be monitored in the control unit 16, and the time history of these measurements can be compared with the known frequency hopping sequence of transmissions on the short range radio link. The channel or channels which are causing the interference on the satellite link can be detected by noting the short range link channels which are in use at the times when the reception quality on the satellite link is poor or the received signal strength is low.

As a second possibility, the average signal quality or signal strength, of signals received at the transceiver 6, could be measured in the control unit

-7-

16. The control unit 16 can then send control signals to the transceiver 10, suspending transmissions on each of the available channels in turn. During a period in which all of the available channels, except one which  
5 results in the appearance of an interfering intermodulation product, are used, the average received signal strength and signal quality will be higher than during a period in which such a channel is used. It is therefore possible to determine in the control unit 16  
10 which channels on the short range radio link are responsible for the interference on the satellite link.

As a third possibility, the control unit 16 can control transmissions from the transceiver 10, in order to make a small change in the power of the signals  
15 transmitted thereby. At the same time, if the control unit 16 monitors the power level of signals received in the satellite transceiver unit 6, the relevant interaction mechanism can be deduced. Thus, the transmit level could be shifted slightly on each  
20 complete cycle of the frequency hopped sequence, so that, if one channel was causing the problem, the interference would move up and down slightly for each cycle of the sequence. For example, we could hold all the frequency hopping channels constant in level, but  
25 every time we got to channel 12 (say), we could alter the level up and down alternately by 1 dB. Then, if the interference was caused by this channel the interferer would move up and down at a rate equal to the repetition rate of the frequency hopping cycle. We  
30 could then effectively probe each of the channels in sequence.

Alternatively, to save having to wait for each complete frequency hopping sequence to finish, we could alternately switch the transmit level on a given  
35 channel up and down slightly each time we transmitted on that channel, and then correlate the changes in

-8-

interferer level with the use of this channel.

5 A further possibility is to apply an encoded modulation to signals transmitted on the short range radio link. For example, a low frequency AM signal could be applied to the transceiver. Such a modulation would have a negligible effect on the reception of the signals at the remote unit 12, but would be translated on to the intermodulation products resulting from combination with the third party signal. Therefore, if 10 the control unit 16 looks for such a code in signals received at the transceiver 6, the presence of such a code will indicate the presence of an interfering intermodulation product, and the code can be used to identify the channel of the short range link which has resulted in that signal. Alternatively, the encoding 15 applied to the signal on the short range link could be a small frequency or phase modulation. Further, the interference phase modulation could be correlated with the modulation pattern of the short range link. If 20 there is any correlation, this can be used to determine that the interference originals in the short range link.

Once it has been determined in the control unit 16 which channel or channels on the short range radio link 25 are responsible for the creation of intermodulation products which interfere with transmissions on the satellite link, action can be taken to prevent further transmissions on that frequency.

A preferred possibility is simply to send a 30 control signal from the control unit 16 to the transceiver 10, preventing further transmissions on that channel. This will cause data, intended to be transmitted on that channel, to be lost, but, if the data are adequately interleaved, this will be no 35 problem, in the same way that interleaving and error correction can avoid significant loss of data if there

-9-

is interference on one of channels in the frequency hopped sequence itself. Moreover, this has the advantage that the remote receiver 12 can operate in the usual way.

5           An alternative is to send a signal from the control unit 16 via the transceiver 10 to the remote unit 12, indicating the channels on which communication is to be suspended, and to negotiate a new hopping sequence between the transceivers 10, 12, which avoids  
10       the relevant channel or channels.

          The result is that there are no transmissions on the channel or channels which cause intermodulation products to appear on the channel of the satellite receiver which is in use, and the overall signal  
15       quality of transmissions on that link will therefore be improved.

          The monitoring steps described above can be repeated at regular intervals as often as is required, for example every 30 seconds, to detect interfering  
20       intermodulation products. Alternatively, the overall signal quality or signal strength can be monitored continuously, and steps can be taken to detect interfering intermodulation products only when it is determined that the overall signal quality of signal  
25       strength has fallen below a particular threshold.

          There is therefore described a system which allows improved communication with a satellite network in the presence of an interfering signal, without requiring the unit to change the channel on which is  
30       communicating with the satellite network.

-10-

**CLAIMS**

1. A radio communications unit, comprising:  
a first transceiver for communicating on a  
selected one of a plurality of channels in a first  
radio frequency band;  
a second transceiver for communicating on channels  
in a second radio frequency band, communications taking  
place on a plurality of channels sequentially;  
means for detecting interference on the selected  
channel in the first radio frequency band, caused by  
transmissions on an identified channel in the second  
radio frequency band; and  
means for preventing transmissions on the  
identified channel.
2. A radio communications unit as claimed in  
claim 1, wherein the means for detecting interference  
on the selected channel comprises means for monitoring  
a signal parameter on the selected channel, and means  
for comparing the time history of these measurements  
with the known sequence of transmissions in the second  
radio frequency band.
3. A radio communications unit as claimed in  
claim 1, wherein the means for detecting interference  
on the selected channel comprises means for monitoring  
an average value of a signal parameter of signals  
received on the selected channel, and means for  
temporarily suspending transmissions on each of the  
available channels in the second radio frequency band  
in turn.
4. A radio communications unit as claimed in  
claim 1, wherein the means for detecting interference  
on the selected channel comprises means for varying  
signals transmitted in the second radio frequency band,  
and means for detecting resulting variations in signals  
detected on the selected channel

1/1

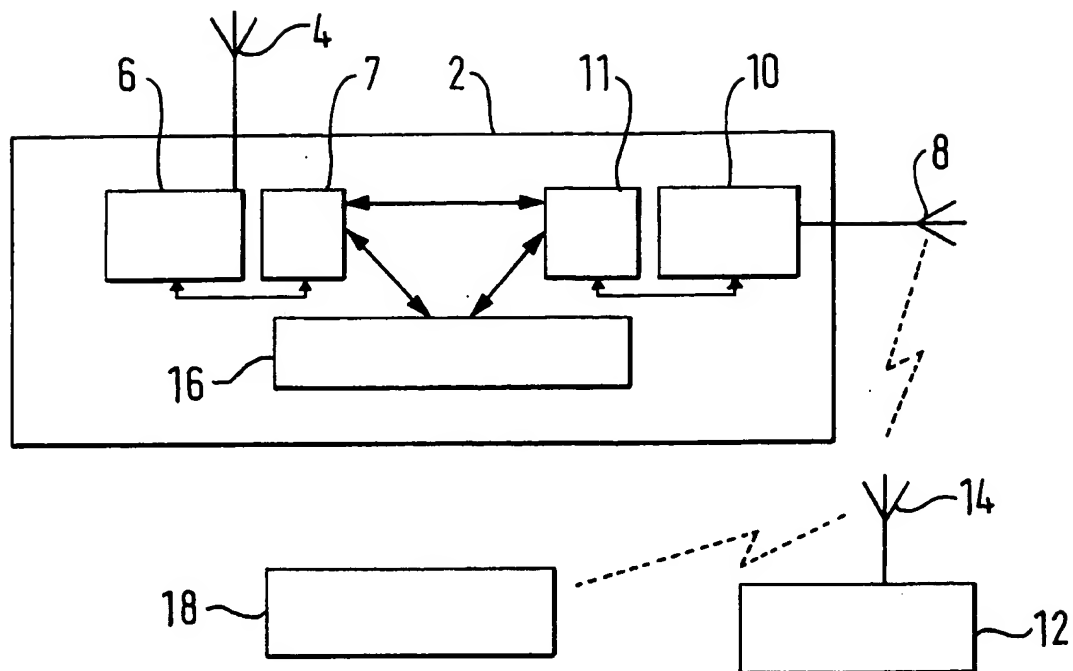


FIG. 1

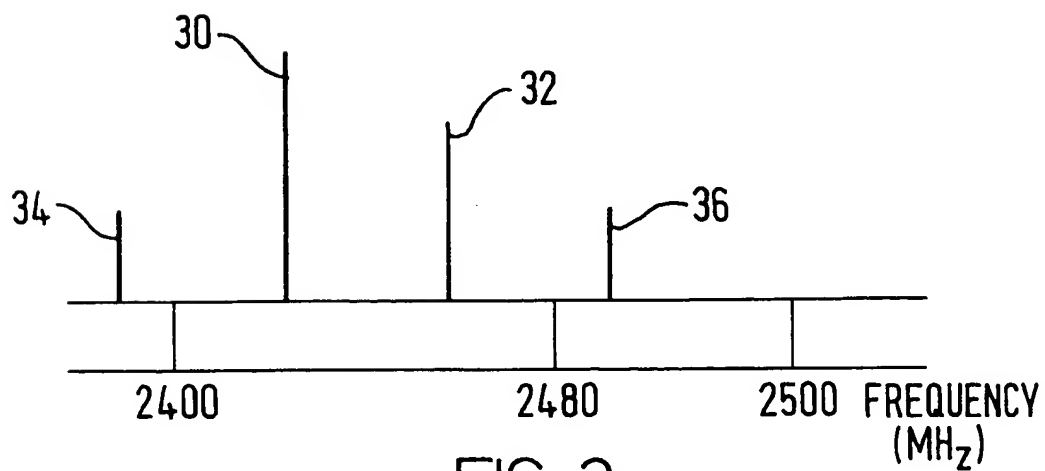


FIG. 2

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 99/04666

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04B17/00 H04B1/10 H04B1/713

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 737 359 A (KOIVU VESA) 7 April 1998 (1998-04-07) * abstract * column 1, line 1 - column 2, line 54 column 3, line 21 - line 44 column 4, line 5 - line 20 column 5, line 21 - line 31 claim 1; figures 1,2 ---	1-4
A	US 5 355 522 A (DEMANGE MARK G) 11 October 1994 (1994-10-11) * abstract * column 1, line 48 - line 64 column 4, line 12 - column 5, line 3 figures 2,8 --- -/--	1-4



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

### \* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

8 November 1999

Date of mailing of the international search report

16/11/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

Authorized officer

López Márquez, T

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 99/04666

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>US 5 428 824 A (KASAI YOSHIHIKO)  27 June 1995 (1995-06-27)  * abstract *  column 1, line 12 -column 2, line 2  column 3, line 25 - line 61  figure 1</p> <p style="text-align: center;">-----</p>	1-4

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 99/04666

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5737359 A	07-04-1998	AU 678052 B	15-05-1997
		AU 7616394 A	03-04-1995
		CN 1114519 A	03-01-1996
		EP 0669073 A	30-08-1995
		FI 940705 A	15-03-1995
		WO 9508246 A	23-03-1995
		JP 8503354 T	09-04-1996
		NO 951886 A	12-07-1995
US 5355522 A	11-10-1994	BR 9306601 A	08-12-1998
		EP 0746916 A	11-12-1996
		JP 7508385 T	14-09-1995
		KR 139393 B	01-07-1998
		MX 9303834 A	01-12-1993
		WO 9400931 A	06-01-1994
US 5428824 A	27-06-1995	JP 2051913 A	21-02-1990
		JP 2546347 B	23-10-1996
		AU 625760 B	16-07-1992
		AU 3993589 A	22-02-1990
		GB 2223146 A, B	28-03-1990
		HK 139893 A	31-12-1993